TITLE OF THE INVENTION

A METHOD OF FABRICATING AN INK-JET PRINT HEAD USING A LIQUID-JET GUIDED LASER

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a method of fabricating a print head for an ink-jet printer, and in particular, to a method of fabricating an ink-jet print head, wherein a liquid-jet guided laser that combines a laser beam and a micro liquid-jet is used to form an ink feeding port of a print head in a wafer or to dice a wafer formed with one or more print heads.

2. Description of the Related Art

[0002] In general, the consumer demand for ink-jet printers has rapidly increased because the ink-jet printers generate little noise and are superior to other printers in resolution. Furthermore, the ink-jet printers enable color implementation.

[0003] Moreover, with the development of semiconductor techniques, the techniques for fabricating print heads that are core components of the ink-jet printers have made rapid progress for the last ten years. As a result, the print heads provided with about 300 ink-jet nozzles and capable of providing a resolution of 1200 dpi are used by being installed in ink cartridges that are disposable after use.

[0004] According to positions for forming at least one ink via or ink feeding port through which ink is supplied to an ink chamber connected to nozzles, such print heads are divided into a common or central feed type in which an ink feeding port is centrally positioned, an edge feed type in which ink feeding ports are positioned at opposite ends, and an individual feed type in which ink feeding ports are positioned in individual chambers.

[0005] FIG. 1 schematically illustrates a print head 10 of a conventional central feed type ink-jet printer.

[0006] Typically, ink is fed from a rear side of a wafer 1 of the print head 10 through an ink via or a first ink feeding passage 2 to a front side of the wafer 1.

[0007] The ink fed through the first ink feeding passage 2 arrives at an ink chamber 4 along a second ink feeding passage 3 formed by a chamber plate 8 and a nozzle plate 9. The ink, temporarily stagnating in the ink chamber 4, is instantaneously heated by heat generated from a heater 6 located below a protective layer 5.

[0008] At this time, explosive bubbles are generated in the ink, so that a part of the ink within the ink chamber 4 is ejected out of the print head 10 through nozzles 7 formed in the top of the ink chamber 4 by the generated bubbles.

[0009] In this print head 10, the chamber plate 8 and the nozzle plate 9 are important elements that affect a flow of ink, an injected form of ink, and injection frequency characteristics. Therefore, much research has been performed on materials, shapes and fabrication methods of the chamber plate 8 and nozzle plate 9.

[0010] The most conventional method among various methods used at present to fabricate print heads in connection with chamber plates and nozzle plates is a monolithic method that employs a photolithographic process.

[0011] A conventional fabrication procedure (method) of a print head 10' according to the monolithic method is illustrated in FIGS. 2A-2E.

[0012] Referring to FIGS. 2A-2E, a rear side of a silicon wafer 1 is formed with a preliminary first ink feeding passage 2' to form a first ink feeding passage 2 of FIGS. 2D and 2E that constructs an ink feeding port, as shown in FIG. 2A, wherein a front side of the wafer 1 is formed with a heater 6 and a protective layer 5.

[0013] At this time, a part of the thickness of the wafer 1 remains without being completely penetrated at the preliminary first ink feeding passage 2'.

[0014] Next, a positive photoresist is formed on the top of the protective layer 5 of the wafer 1 and then patterned by a photolithography process using a photomask (not shown). As a result, a positive photoresist mold 3' which is a sacrifice layer is formed on the protective layer 5, as shown in FIG. 2B. The positive photoresist mold 3 is later removed by etching, thereby providing a flow passage construction for a second ink feeding passage 3, an ink chamber 4, or the like. The thickness of the positive photoresist mold 3' is about 30 to 40 μm to correspond to the height of the second ink feeding passage 3 and the ink chamber 4 which are formed later.

[0015] After the positive photoresist mold 3' is formed on the top of the protective layer 5, on the front side of the wafer 1 is coated a photosensitive epoxy resin layer as a negative photoresist.

[0016] Next, the photosensitive epoxy resin layer is exposed through a photomask (not shown) formed with a nozzle pattern and is then patterned by a micro-punching or lithography process. As a result, a chamber/nozzle plate 9' formed with nozzles 7' is formed as shown in FIG. 2C.

[0017] After the chamber/nozzle plate 9' is formed, a part of the wafer 1formed with the preliminary first ink feeding passage 2' in the rear side thereof is removed, thereby forming the first ink feeding passage 2.

[0018] Next, if the photoresist mold 3' is dissolved by a solvent, the ink chamber 4 and the second ink feeding passage 3 are formed and the fabrication of the print head 10' is terminated, as shown in FIGS. 2D and 2E.

[0019] In the method of fabricating the print head 10' according to the monolithic method, in order to form the preliminary first ink passage 2' and the first ink passage 2, widely used are a wet etching method that chemically etches the wafer 1, a dry etching method, such as reactive ion etching or deep reactive ion etching, that etches a wafer 1 using plasma, and a grit blasting method that etches the wafer 1 by ejecting very fine sands, such as grits, against the wafer 1 at a very rapid velocity.

[0020] However, the wet etching method has a disadvantage in that because the wafer 1 is chemically etched, the process time is very long and it is difficult to precisely control a space tolerance when very fine impurities are present on the wafer 1.

[0021] The dry etching method using plasma has an advantage in that the process time is relatively short because the etching rate is about 2 to 10 μm/min. However, the dry etching method has a disadvantage in that process costs are high because process equipment is expensive, and it is difficult to control a taper angle of wall surfaces as being etched because the walls are isotropically etched so that an angle of the etched walls approaches about 90°.

[0022] In addition, the grit blasting method has a disadvantage in that because the fine sands are used, the sands are apt to cause contamination by entering into a structure of the

wafer 1 to construct a micro electromechanical system during the process, the accuracy in this processing is inferior, and a post process of removing the sands is required after the process is completed.

SUMMARY OF THE INVENTION

[0023] The present invention has been conceived to solve the above-mentioned and/or other problems occurring in the related art, and a principal aspect of the present invention is to provide a method of fabricating an ink-jet print head, wherein the method comprises a process of forming an ink feeding port of the print head using a liquid-jet guided laser that combines liquid-jet and laser, so as to prevent thermal damage, save process costs and reduce a process time.

[0024] Another aspect of the present invention is to provide a method of fabricating an ink-jet print head, wherein the method comprises a process of dicing a wafer formed with one or more print heads using a liquid-jet guided laser so as to prevent thermal damage, save process costs and reduce a process time.

[0025] Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

[0026] In order to achieve the above-mentioned and/or other aspects of the present invention, there is provided a method of fabricating an ink-jet print head using a liquid-jet guided laser. The method comprises at least one process of forming an ink feeding port through a wafer that constitutes the ink-jet print head, wherein the ink feeding port forming process comprises fixing the wafer to a stage in a chamber to perform the process; and processing the ink feeding port in the wafer to a desired depth using the liquid-jet guided laser.

[0027] The operation of fixing the wafer comprises: loading the wafer in a loader; moving the wafer loaded in the loader to the stage in the chamber; and arranging and fixing the wafer in position in the stage.

[0028] The operation of processing the ink feeding port comprises: illuminating a laser beam guided by a liquid-jet having a diameter in the range of 10 to 500 μm through the liquid-jet guided laser; and moving the stage, where the wafer is fixed, along an ink feeding port pattern.

[0029] A material of a liquid state having a pressure in the range of 1 to 7,000 bars is preferably used as the liquid-jet, and one of a diode-pumped solid laser beam and a gas laser beam is preferably used as the laser beam.

[0030] Alternatively, the illumination of the laser beam may be achieved by illuminating the laser beam guided by the liquid-jet having a diameter in the range of 30 to 50 μm through the liquid-jet guided laser.

[0031] In addition, the process of forming the ink feeding port further comprises cleaning an organic material having flown in surfaces of the wafer at the time of forming the ink feeding port; and drying the cleaned wafer.

[0032] The method of fabricating the ink-jet print head may further comprise a process of dicing the wafer formed with one or more print heads.

[0033] The process of dicing the wafer comprises fixing the wafer to a stage in a chamber to perform the dicing process; and dicing the wafer using the liquid-jet guided laser.

[0034] In this embodiment, a silicon wafer having a thickness in the range of 100 to 600 μm may be used as the silicon wafer, and one or more ink feeding ports may be formed on one of a central feed type print head, an edge feed type print head, and an individual feed type print head.

[0035] In order to achieve the above-mentioned and/or other aspects according to another embodiment of the present invention, there is also provided a method of fabricating an ink-jet print head using a liquid-jet guided laser.The method comprises a process of dicing a wafer formed with a plurality of print heads, wherein the dicing process comprises fixing the wafer to a stage of a chamber to perform the process; and dicing the wafer using the liquid-jet guided laser.

[0036] The operation of fixing the wafer comprises: loading the wafer in a loader; moving the wafer loaded in the loader to the stage in the chamber; and arranging and fixing the wafer in position in the stage.

[0037] The operation of dicing the wafer comprises: illuminating a laser beam guided by a liquid-jet having a diameter in the range of 30 to 100μm through the liquid-jet guided laser; and moving the stage, on which the wafer is fixed, along a dicing pattern.

[0038] A material of a liquid state having a pressure in the range of 1 to 7,000 bars is preferably used as the liquid-jet, and one of a diode-pumped solid laser beam and a gas laser beam is preferably used as the laser beam.

[0039] In addition, the dicing process further comprises cleaning an organic material having flown in the print heads cut in the form of chips at the time of dicing the wafer; and drying the cleaned print heads in the form of chips.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] These and/or other aspects and advantages of the present invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

[0041] FIG. 1 is a cross-sectional view of a conventional print head;

[0042] FIGS. 2A to 2E are process charts illustrating a method of fabricating the conventional ink-jet print head shown in FIG. 1;

[0043] FIG. 3 is a schematic view illustrating an operation of an example of a liquid-jet guided laser used in the method of fabricating an ink-jet print head using the liquid-jet guided laser according to an embodiment of the present invention;

[0044] FIGS. 4A and 4B are photographs illustrating a form of a preliminary first ink feeding passage formed according to the method of fabricating the ink-jet print head using the liquid-jet guided laser shown in FIG. 3;

[0045] FIG. 5 is a flowchart illustrating processes in the method of fabricating an ink-jet print head using a liquid-jet guided laser according to another embodiment of the present invention;

[0046] FIG. 6 is a flowchart illustrating a process of forming a preliminary first ink feeding passage in the method of fabricating the ink-jet print head using the liquid-jet guided laser shown in FIGS. 3 and 5; and

[0047] FIG. 7 is a flowchart illustrating a dicing process in the method of fabricating the ink-jet print head using the liquid-jet guided laser shown in FIGS. 3 and 5.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0048] Herein below, the inventive method of fabricating an ink-jet print head using a liquid-jet guided laser will be described in detail with reference to the accompanying drawings. In the drawings and detailed description, the constituent parts same with those of the prior art will be illustrated and described by reference numerals same with those used in describing the prior art.

[0049] FIG. 5 is a flowchart illustrating processes in a method of fabricating an ink-jet print head using a liquid-jet guided laser according to an embodiment of the present invention.

[0050] At first, like the fabrication of a conventional print head 10 shown in FIG. 2A, a silicon wafer 1 having a thickness in the range of 100 to 600 μm is formed with a heater 6 and a protective layer 5 on a front side thereof within a chamber (not shown) by performing a coating process, an ion implantation process, a photolithography process, etc. (S1), and then a process of forming a preliminary first ink feeding passage 2' on a rear side of the wafer 1 is performed to form a first ink feeding passage 2 constituting an ink via or an ink feeding port (S2).

[0051] That is, as shown in FIG. 6, the wafer 1 is loaded in a loader (not shown), which may be a conventional loader, with the rear side of the wafer oriented upward so that the wafer 1 is moved into the chamber (not shown) to perform a liquid-jet guided laser processing (S2a).

[0052] Next, the loader moves the wafer 1 to a stage (not shown) in the chamber so that a liquid-jet guided laser processing is performed (S2b), and the wafer 1 is arranged and fixed in position by a gripper (not shown), which may be a conventional gripper, (S2c).

[0053] When reference coordinates are set according to computer-aided design (CAD) data stored in a personal computer (PC) after the wafer 1 is fixed, the stage on which the wafer is fixed moves in a desired direction according to a program input in the PC at a velocity of about 100 mm/sec, for example.

[0054] Simultaneously with this process, the liquid-jet guided laser 100 (FIG. 3) fixed at a predetermined position injects a liquid-jet 101 and illuminates a laser beam 102 guided by the liquid-jet 101 through a nozzle head 120.

[0055] Therefore, the wafer 1 is etched by the laser beam 102 guided along an inner wall of the liquid-jet 101, thereby forming a trench or the preliminary first ink feeding passage 2' to a

predetermined depth, as shown in FIGS. 4A and 4B (S2d).

[0056] At this time, the liquid-jet 101 injected through the nozzle head 120 of the liquid-jet guided laser 100 is controlled to have a diameter in the range of 10 to 500 μm.

[0057] That is, although it is preferable that the diameter of the liquid-jet exceeds 150 μm in order to reduce the process time, it is possible to use another liquid-jet having a diameter in the range of 30 to 50 μm as desired.

[0058] The pressure of the liquid-jet 101 is set in the range of 1 to 7,000 bars, and preferably set to about 70 bars. A liquid used as the liquid-jet 101 may be any material in a liquid state.

[0059] In addition, the temperature within the chamber to perform the liquid-jet guided laser processing remains at a normal temperature.

[0060] The liquid-jet guided laser 100 used to inject the liquid-jet 101 and to illuminate the laser beam 102 may be a liquid-jet guided laser that comprises a laser beam illumination lens section 110 connected to a laser beam source (not shown), such as a diode-pumped solid laser source and a gas laser source, through a laser beam guide 103, and a nozzle head 120 that injects the liquid-jet 101 fed through a liquid line 105 and illuminates the laser beam 102 illuminated from the laser beam illumination lens section 110 after coaxially combining them, as shown in FIG. 3 by way of an example.

[0061] The laser beam illumination lens section 110 comprises a collimator 111 to collimate the laser beam 102 transmitted from the laser beam guide 103, and a focusing lens 113 to focus and illumate the collimated laser beam 112 through a cone-shaped space 124 located in a base 122 of the nozzle head 120.

[0062] The nozzle head 120 comprises a window 123 to pass the laser beam 102 illuminated to the cone-shaped space 124, a liquid feeding duct 121 connected to the liquid line 105, and a nozzle block to illuminate the laser beam 102 and inject the liquid-jet 101 through a central bore hole 127 after the laser beam 102 and the liquid-jet 101 pass through the window 123 and the liquid feeding duct 121, respectively.

[0063] The liquid-jet 101, flowing downward of the wafer 1 after being injected to the wafer 1 through the nozzle block 125, is recovered through a liquid collection section (not shown) formed below the chamber and is fed to the nozzle head 120 again through the liquid line 105

by a pump (not shown) or the like.

[0064] In this manner, after the preliminary first ink feeding passage 2' is formed in the wafer 1, the wafer 1 is transmitted to a chamber (not shown) to perform a cleaning process.

[0065] The wafer 1, transmitted to the chamber to perform the cleaning process, is cleaned to remove organic materials having flown in the surfaces of the wafer 1 at the time of forming the preliminary ink feeding passage 2' (S2e) and then the wafer 1 is dried (S2f).

[0066] Thereafter, the wafer 1 is moved again to the chamber to perform the photolithography process or the like, and then a chamber/nozzle plate 9' is formed on the wafer 1, wherein nozzles 7' are formed in a front side of the chamber/nozzle plate 9' by the same method as that used to fabricate the conventional print head 10 shown in FIGS. 2B and 2C (S3).

[0067] After the chamber/nozzle plate 9' is formed, the wafer 1 is moved again by the loader to the stage in the chamber to perform a liquid-jet guided laser processing, and then a part of the wafer 1having a rear side formed with the preliminary first ink feeding passage 2' is removed by the same method as that used to form the preliminary first ink feeding passage 2' as described above, thereby forming the first ink feeding passage 2 (S4). At this time, one or more first ink feeding passages 2 are formed in one of a central feed type, an edge feed type and an individual feed type ink-jet printer according to a design thereof.

[0068] Next, the wafer 1 is moved again to the chamber to perform the photolithography process or the like, and then an ink chamber 4 and a second ink feeding passage 3 are formed when the photoresist mold 3' is solved by a solvent, as shown in FIG. 2E (S5).

[0069] As a result, the wafer 1 is formed with a plurality of print heads 10' in a grid form.

[0070] The wafer 1 formed with the plurality of print heads 10' as described above is moved again to the chamber, in which the liquid-jet guided laser processing is performed, to perform a dicing process.

[0071] The dicing process of dicing the wafer 1 is performed in substantially the same manner as the process of forming the preliminary first ink feeding passage 2' or the first ink feeding passage 2 as described above, except that the liquid-jet 101 having a diameter in the range of 30 to 100 μm, preferably of 50 μm, is injected, and the laser beam 102 guided by the liquid-jet 101 is illuminated through the liquid-jet guided laser 100 (S6).

[0072] That is, as shown in FIG. 7, after the wafer 1 is loaded on the loader (S6a), the wafer 1 is moved to the stage in the chamber, in which the liquid-jet guided laser processing is performed, (S6b), and then the wafer 1 is arranged and fixed on a position of the stage (S6c).

[0073] Thereafter, the wafer 1 is diced when the stage, on which the wafer 1 is fixed, is moved along a dicing pattern at a velocity of 100 mm/sec while the laser beam 102, guided by the liquid-jet 101 having a diameter in the range of 30 to 100 μm, is being illuminated through the liquid-jet guided laser 100, thereby cutting the wafer 1 into the individual print heads 10' in the form of chips (S6d).

[0074] After the wafer 1 is diced, if the individual print heads 10' cut in the form of chips are cleaned to remove organic materials having flown in the surfaces of the print heads 10' (6e), and then the print heads are dried (S6f), the fabrication of all print heads 10' is terminated.

[0075] While the embodiments of the present invention have been shown and described with reference to the preferred embodiments thereof in order to illustrate the principle of the present invention, the present invention is not limited to the embodiments. It will be understood that various modifications and changes can be made by those skilled in the art without departing from the spirit and scope of the invention as defined by the appended claims and their equivalents.

[0076] For example, in the method of forming the print head 10' described above, although it has been described that the first ink feeding passage 2 is formed through two processes using the liquid-jet guided laser 100, it can be formed through one process or through more than two processes according to the methods of forming the print head 10'.

[0077] In addition, although it has been described that both processes of forming the print head 10' and dicing the wafer 1' employ the liquid-jet guided laser 100, it will be possible to employ the liquid-jet guided laser 100 in only one of the two processes.

[0078] As described above, because the method of fabricating an ink-jet print head uses a liquid-jet guided laser that combines laser and a liquid-jet, it is possible to form an ink feeding port of the print head or to dice a wafer after the print head is formed under a normal temperature without using a mask that is essentially required in a conventional wet etching method or dry etching method. As a result, it is possible to achieve effects that a thermal damage of the print head can be prevented and process costs can be saved.

[0079] Furthermore, the method of fabricating an ink-jet print head controls the three-dimensional shape of an ink feeding port by optimized design data of a PC. Therefore, it is possible to more freely and precisely implement the shape of the ink feeding port and to reduce a process time. In fact, according to a test in which a 10 mm x 5 mm surface was processed to a depth of 500 μm under the condition where the moving velocity of the stage was100 mm/sec, and the diameter and pressure of the liquid-jet were about 150 μm and about 70 bars, respectively, the required time was about 55 sec.